New bistable proton-electron hybrid memory element

V.Joshkin[a),b)], D. van der Weide[b)] and M.Lagally[a)]

[a]MS&E Department, Engineering Research Building, UW-Madison, Madison, WI 53706

[b]ECE Department, Engineering Hall, UW-Madison, Madison, WI 53706

ABSTRACT

The leakage current in ultra-thin dielectrics and low capacitance are challenging tasks for the technology of nanosized nonvolatile memory elements. Our approach to get the dilemma over memory element minimization solved is a development of a new bistable proton-electron hybrid memory element, which utilizes a self-assembling "defect-free" technology of electrical double layers. The footprint's area of such device can be smaller than 50nm x 50nm and cutoff frequency for this element could be over 1MHz despite significant decrease of double layer capacitance vs. signal frequency. The memory element comprises a Schottky or p-i-n nanoneedle diode which is immersed into an ionic medium and whose bias is determined by the built-in potential of a double layer based transition element formed around the depletion and bulk (electrode) regions of nanodiode. It was found that charging and discharging processes of the transition element are determined by the surface curvature of electrodes as well as by properties of ionic medium. It was shown that under certain conditions the transition element can be considered as a semiconductor diode with protons as majority charge carriers and which is connected in series with two double layer capacitors. The feature has been used for building bistable memory elements that possess low (< 9 k Ω) and high (>175 k Ω) dynamic resistance at the low and high binary positions, respectively.